

NCS20081/2/4, NCV20081/2/4

1.2 MHz, 42 μ A Low Power Operational Amplifier

The NCS20081/2/4 is a family of single, dual and quad Operational Amplifiers (Op Amps) with 1.2 MHz of Gain-Bandwidth Product (GBWP) While consuming only 42 μ A of Quiescent current per opamp.. The NCS2008x has Input Offset Voltage of 4 mV and operates from 1.8 V to 5.5 V supply voltage over a wide temperature range (-40°C to $+125^{\circ}\text{C}$). The Rail-to-Rail In/Out operation allows the use of the entire supply voltage range while taking advantage of the 1.2 MHz GBWP. Thus, this family offers superior performance over many industry standard parts. These devices are AEC-Q100 qualified which is denoted by the NCV prefix.

NCS2008x's low current consumption and low supply voltage performance in space saving packages, makes them ideal for sensor signal conditioning and low voltage current sensing applications in Automotive, Consumer and Industrial markets.

Features

- Wide Bandwidth: 1.2 MHz
- Low Supply Current/ Channel: 42 μ A typ ($V_S = 1.8$ V)
- Low Input Offset Voltage: 4 mV max
- Wide Supply Range: 1.8 V to 5.5 V
- Wide Temperature Range: -40°C to $+125^{\circ}\text{C}$
- Rail-to-Rail Input and Output
- Unity Gain Stable
- Available in Single, Dual and Quad Packages
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

Applications

- Automotive
- Battery Powered/ Portable
- Sensor Signal Conditioning
- Low Voltage Current Sensing
- Filter Circuits
- Unity Gain Buffer

This document contains information on some products that are still under development. ON Semiconductor reserves the right to change or discontinue these products without notice.



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SC70-5
CASE 419A



TSOP-5/SOT23-5
CASE 483



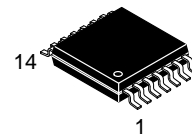
Micro8™/MSOP8
CASE 846A



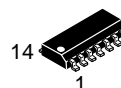
SOIC-8
CASE 751



TSSOP-8
CASE 948S



TSSOP-14
CASE 948G



SOIC-14
CASE 751A



UDFN6
CASE 517AP

DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 2 of this data sheet.

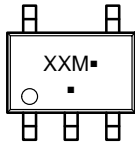
ORDERING INFORMATION

See detailed ordering and shipping information on page 3 of this data sheet.

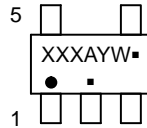
NCS20081/2/4, NCV20081/2/4

MARKING DIAGRAMS

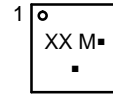
Single Channel Configuration NCS20081, NCV20081



SC70-5
CASE 419A

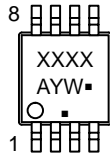


TSOP-5/SOT23-5
CASE 483

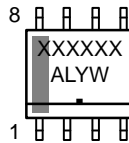


UDFN6
CASE 517AP

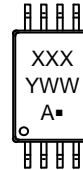
Dual Channel Configuration NCS20082, NCV20082



Micro8™/MSOP8
CASE 846A

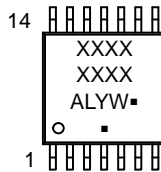


SOIC-8
CASE 751

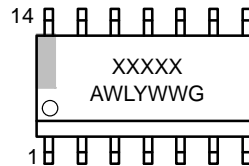


TSSOP-8
CASE 948S

Quad Channel Configuration NCS20084, NCV20084



TSSOP-14
CASE 948G



SOIC-14
CASE 751A

XXXXX = Specific Device Code
 A = Assembly Location
 WL, L = Wafer Lot
 Y = Year
 WW, W = Work Week
 G or ■ = Pb-Free Package

(Note: Microdot may be in either location)

NCS20081/2/4, NCV20081/2/4

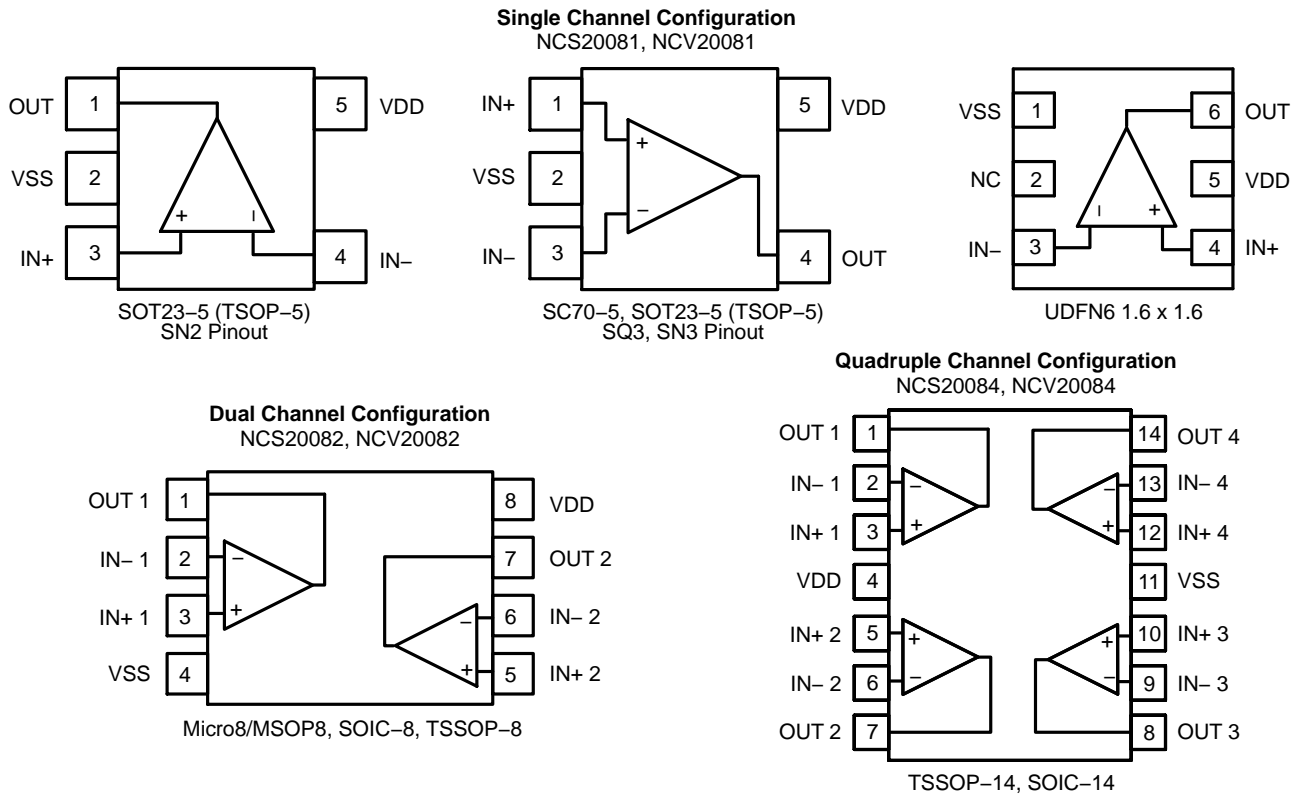


Figure 1. Pin Connections

ORDERING INFORMATION

| Device | Configuration | Automotive | Marking | Package | Shipping† |
|------------------|---------------|------------|----------|----------------|-------------------------------------------------|
| NCS20081SQ3T2G | Single | No | AAP | SC70 | Contact local sales office for more information |
| NCS20081SN2T1G | | | AER | SOT23-5/TSOP-5 | |
| NCS20081SN3T1G | | | AEU | SOT23-5/TSOP-5 | |
| NCS20081MUTAG | | | AP | UDFN6 | |
| NCV20081SQ3T2G* | | Yes | AAP | SC70 | |
| NCV20081SN2T1G* | | | AER | SOT23-5/TSOP-5 | |
| NCV20081SN3T1G* | | | AEU | SOT23-5/TSOP-5 | |
| NCS20082DMR2G | Dual | No | 2K82 | Micro8/MSOP8 | |
| NCS20082DR2G | | | NCS20082 | SOIC-8 | |
| NCS20082DTBR2G | | | K82 | TSSOP-8 | |
| NCV20082DMR2G* | | Yes | 2K82 | Micro8/MSOP8 | |
| NCV20082DR2G* | | | NCS20082 | SOIC-8 | |
| NCV20082DTBR2G* | | | K82 | TSSOP-8 | |
| NCS20084DR2G** | Quad** | No | 20084 | SOIC-14 | |
| NCS20084DTBR2G** | | | 284 | TSSOP-14 | |
| NCV20084DR2G** | | Yes | 20084 | SOIC-14 | |
| NCV20084DTBR2G** | | | 284 | TSSOP-14 | |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D

*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable.

**In Development. Not yet released.

NCS20081/2/4, NCV20081/2/4

ABSOLUTE MAXIMUM RATINGS (Note 1)

| Rating | Symbol | Limit | Unit | |
|--------------------------------------------------------|---------------------|----------------------------------|--------------------|---|
| Supply Voltage ($V_{DD} - V_{SS}$) (Note 2) | V_S | 6 | V | |
| Input Voltage | V_I | $V_{SS} - 0.5$ to $V_{DD} + 0.5$ | V | |
| Differential Input Voltage | V_{ID} | $\pm V_S$ | V | |
| Maximum Input Current | I_I | ± 10 | mA | |
| Maximum Output Current | I_O | ± 100 | mA | |
| Continuous Total Power Dissipation (Note 2) | P_D | 200 | mW | |
| Maximum Junction Temperature | T_J | 150 | $^{\circ}\text{C}$ | |
| Storage Temperature Range | T_{STG} | -65 to 150 | $^{\circ}\text{C}$ | |
| Mounting Temperature (Infrared or Convection – 20 sec) | T_{mount} | 260 | $^{\circ}\text{C}$ | |
| ESD Capability (Note 3) | Human Body Model | ESD _{HBM} | 2000 | V |
| | Charge Device Model | ESD _{CDM} | 2000 | |
| Latch-Up Current (Note 4) | I_{LU} | 100 | mA | |
| Moisture Sensitivity Level (Note 5) | MSL | Level 1 | | |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

- Refer to ELECTRICAL CHARACTERISTICS for Safe Operating Area.
- Continuous short circuit operation to ground at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150 $^{\circ}\text{C}$. Output currents in excess of the maximum output current rating over the long term may adversely affect reliability. Shorting output to either VDD or VSS will adversely affect reliability.
- This device series incorporates ESD protection and is tested by the following methods:
 ESD Human Body Model tested per JEDEC standard Js-001-2017 (AEC-Q100-002)
 ESD Charged Device Model tested per JEDEC standard JS-002-2014 (AEC-Q100-011)
- Latch-up Current tested per JEDEC standard JESD78E (AEC-Q100-004)
- Moisture Sensitivity Level tested per IPC/JEDEC standard: J-STD-020A

THERMAL INFORMATION

| Parameter | Symbol | Channels | Package | Single Layer Board (Note 6) | Multi-Layer Board (Note 7) | Unit |
|----------------------------------------|---------------|----------|----------------|-----------------------------|----------------------------|----------------------|
| Junction to Ambient Thermal Resistance | θ_{JA} | Single | SC-70 | 491 | 444 | $^{\circ}\text{C/W}$ |
| | | | SOT23-5/TSOP-5 | 310 | 247 | |
| | | | UDFN6 | 278 | 239 | |
| | | Dual | Micro8/MSOP8 | 236 | 167 | |
| | | | SOIC-8 | 190 | 131 | |
| | | | TSSOP-8 | 253 | 194 | |
| | | Quad | SOIC-14 | 130 | 99 | |
| | | | TSSOP-14 | 178 | 140 | |

- Value based on 1S standard PCB according to JEDEC51-3 with 1.0 oz copper and a 300 mm² copper area
- Value based on 1S2P standard PCB according to JEDEC51-7 with 1.0 oz copper and a 100 mm² copper area

OPERATING RANGES

| Parameter | Symbol | Min | Max | Unit |
|----------------------------|-----------|----------------|----------------|--------------------|
| Operating Supply Voltage | V_S | 1.8 | 5.5 | V |
| Differential Input Voltage | V_{ID} | | V_S | V |
| Input Common Mode Range | V_{ICM} | $V_{SS} - 0.2$ | $V_{DD} + 0.2$ | V |
| Ambient Temperature | T_A | -40 | 125 | $^{\circ}\text{C}$ |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

NCS20081/2/4, NCV20081/2/4

ELECTRICAL CHARACTERISTICS AT $V_S = 1.8\text{ V}$

$T_A = 25^\circ\text{C}$; $R_L \geq 10\text{ k}\Omega$; $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise noted.

Boldface limits apply over the specified temperature range, $T_A = -40^\circ\text{C}$ to 125°C . (Note 8)

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|--------------------------------|--------------------------|-------------------------------------------|-----------|-----|-------------|------------------------------|
| INPUT CHARACTERISTICS | | | | | | |
| Input Offset Voltage | V_{OS} | | | 0.5 | 3.5 | mV |
| | | | | | 4 | mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | | | 1 | | $\mu\text{V}/^\circ\text{C}$ |
| Input Bias Current (Note 8) | I_{IB} | | | 1 | | pA |
| | | | | | 1500 | pA |
| Input Offset Current (Note 8) | I_{OS} | | | 1 | | pA |
| | | | | | 1100 | pA |
| Channel Separation | XTLK | $f = 1\text{ kHz}$ | | 125 | | dB |
| Differential Input Resistance | R_{ID} | | | 10 | | $\text{G}\Omega$ |
| Common Mode Input Resistance | R_{IN} | | | 10 | | $\text{G}\Omega$ |
| Differential Input Capacitance | C_{ID} | | | 1 | | pF |
| Common Mode Input Capacitance | C_{CM} | | | 5 | | pF |
| Common Mode Rejection Ratio | CMRR | $V_{CM} = V_{SS} - 0.2$ to $V_{DD} + 0.2$ | 48 | 73 | | dB |
| | | $V_{CM} = V_{SS} + 0.2$ to $V_{DD} - 0.2$ | 45 | | | |

| | | | | | | |
|-------------------------------|-----------|------------------------------------------------------------------------|-----------|-----|-----------|----|
| OUTPUT CHARACTERISTICS | | | | | | |
| Open Loop Voltage Gain | A_{VOL} | | 86 | 120 | | dB |
| | | | 80 | | | |
| Short Circuit Current | I_{SC} | Output to positive rail, sinking current | | 15 | | mA |
| | | Output to negative rail, sourcing current | | 11 | | |
| Output Voltage High | V_{OH} | Voltage output swing from positive rail $V_{OH} = V_{DD} - V_{OUT}$ | | 3 | 19 | mV |
| | | | | | 20 | |
| Output Voltage Low | V_{OL} | Voltage output swing from negative rail $V_{OL} = V_{OUT} - V_{SS}$ | | 3 | 19 | mV |
| | | | | | 20 | |

| | | | | | | |
|----------------------------|----------|-----------------------------------------|------------------------|---------------|--|------------------------|
| AC CHARACTERISTICS | | | | | | |
| Unity Gain Bandwidth | UGBW | | | 1.2 | | MHz |
| Slew Rate at Unity Gain | SR | $V_{IN} = 1.2\text{ Vpp}$, Gain = 1 | | 0.4 | | $\text{V}/\mu\text{s}$ |
| Phase Margin | ψ_m | | | 60 | | $^\circ$ |
| Gain Margin | A_m | | | 19 | | dB |
| Settling Time | t_S | $V_{IN} = 1.2\text{ Vpp}$, Gain = 1 | Settling time to 0.1% | 5 | | μs |
| | | | Settling time to 0.01% | 6 | | |
| Open Loop Output Impedance | Z_{OL} | | | See Figure 25 | | Ω |

| | | | | | | |
|--------------------------------------|-------|------------------------------------------------------------|--|---------------------|----|------------------------------|
| NOISE CHARACTERISTICS | | | | | | |
| Total Harmonic Distortion plus Noise | THD+N | $V_{IN} = 1.2\text{ Vpp}$, $f = 1\text{ kHz}$, $A_v = 1$ | | 0.005 | | % |
| Input Referred Voltage Noise | e_n | $f = 1\text{ kHz}$ | | 30 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| | | | | $f = 10\text{ kHz}$ | 24 | |
| Input Referred Current Noise | i_n | $f = 1\text{ kHz}$ | | 300 | | $\text{fA}/\sqrt{\text{Hz}}$ |

| | | | | | | |
|--------------------------------|----------|----------------------|-----------|----|-----------|---------------|
| SUPPLY CHARACTERISTICS | | | | | | |
| Power Supply Rejection Ratio | PSRR | No Load | 67 | 90 | | dB |
| | | | 64 | | | |
| Power Supply Quiescent Current | I_{DD} | Per channel, no load | | 42 | 60 | μA |

8. Performance guaranteed over the indicated operating temperature range by design and/or characterization.

NCS20081/2/4, NCV20081/2/4

ELECTRICAL CHARACTERISTICS AT $V_S = 3.3\text{ V}$

$T_A = 25^\circ\text{C}$; $R_L \geq 10\text{ k}\Omega$; $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise noted.

Boldface limits apply over the specified temperature range, $T_A = -40^\circ\text{C}$ to 125°C . (Note 9)

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|--------------------------------|--------------------------|-------------------------------------------|-----------|-----|-------------|------------------------------|
| INPUT CHARACTERISTICS | | | | | | |
| Input Offset Voltage | V_{OS} | | | 0.5 | 3.5 | mV |
| | | | | | 4 | mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | | | 1 | | $\mu\text{V}/^\circ\text{C}$ |
| Input Bias Current (Note 9) | I_{IB} | | | 1 | | pA |
| | | | | | 1500 | pA |
| Input Offset Current (Note 9) | I_{OS} | | | 1 | | pA |
| | | | | | 1100 | pA |
| Channel Separation | XTLK | $f = 1\text{ kHz}$ | | 125 | | dB |
| Differential Input Resistance | R_{ID} | | | 10 | | $\text{G}\Omega$ |
| Common Mode Input Resistance | R_{IN} | | | 10 | | $\text{G}\Omega$ |
| Differential Input Capacitance | C_{ID} | | | 1 | | pF |
| Common Mode Input Capacitance | C_{CM} | | | 5 | | pF |
| Common Mode Rejection Ratio | CMRR | $V_{CM} = V_{SS} - 0.2$ to $V_{DD} + 0.2$ | 53 | 76 | | dB |
| | | $V_{CM} = V_{SS} + 0.2$ to $V_{DD} - 0.2$ | 48 | | | |

| | | | | | | |
|-------------------------------|-----------|------------------------------------------------------------------------|-----------|-----|-----------|----|
| OUTPUT CHARACTERISTICS | | | | | | |
| Open Loop Voltage Gain | A_{VOL} | | 90 | 120 | | dB |
| | | | 86 | | | |
| Short Circuit Current | I_{SC} | Output to positive rail, sinking current | | 15 | | mA |
| | | Output to negative rail, sourcing current | | 11 | | |
| Output Voltage High | V_{OH} | Voltage output swing from positive rail $V_{OH} = V_{DD} - V_{OUT}$ | | 3 | 24 | mV |
| | | | | | 25 | |
| Output Voltage Low | V_{OL} | Voltage output swing from negative rail $V_{OL} = V_{OUT} - V_{SS}$ | | 3 | 24 | mV |
| | | | | | 25 | |

| | | | | | | |
|----------------------------|----------|-----------------------------------------|------------------------|---------------|--|------------------------|
| AC CHARACTERISTICS | | | | | | |
| Unity Gain Bandwidth | UGBW | | | 1.2 | | MHz |
| Slew Rate at Unity Gain | SR | $V_{IN} = 2.5\text{ Vpp}$, Gain = 1 | | 0.4 | | $\text{V}/\mu\text{s}$ |
| Phase Margin | ψ_m | | | 60 | | $^\circ$ |
| Gain Margin | A_m | | | 18 | | dB |
| Settling Time | t_S | $V_{IN} = 2.5\text{ Vpp}$, Gain = 1 | Settling time to 0.1% | 5 | | μs |
| | | | Settling time to 0.01% | 6 | | |
| Open Loop Output Impedance | Z_{OL} | | | See Figure 25 | | Ω |

| | | | | | | |
|--------------------------------------|-------|------------------------------------------------------------|--|---------------------|----|------------------------------|
| NOISE CHARACTERISTICS | | | | | | |
| Total Harmonic Distortion plus Noise | THD+N | $V_{IN} = 2.5\text{ Vpp}$, $f = 1\text{ kHz}$, $A_v = 1$ | | 0.005 | | % |
| Input Referred Voltage Noise | e_n | $f = 1\text{ kHz}$ | | 30 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| | | | | $f = 10\text{ kHz}$ | 24 | |
| Input Referred Current Noise | i_n | $f = 1\text{ kHz}$ | | 300 | | $\text{fA}/\sqrt{\text{Hz}}$ |

| | | | | | | |
|--------------------------------|----------|----------------------|-----------|----|-----------|---------------|
| SUPPLY CHARACTERISTICS | | | | | | |
| Power Supply Rejection Ratio | PSRR | No Load | 67 | 90 | | dB |
| | | | 64 | | | |
| Power Supply Quiescent Current | I_{DD} | Per channel, no load | | 42 | 60 | μA |

9. Performance guaranteed over the indicated operating temperature range by design and/or characterization.

NCS20081/2/4, NCV20081/2/4

ELECTRICAL CHARACTERISTICS AT $V_S = 5.5\text{ V}$

$T_A = 25^\circ\text{C}$; $R_L \geq 10\text{ k}\Omega$; $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise noted.

Boldface limits apply over the specified temperature range, $T_A = -40^\circ\text{C}$ to 125°C . (Note 10)

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|--------------------------------|--------------------------|-------------------------------------------|-----------|-----|-------------|------------------------------|
| INPUT CHARACTERISTICS | | | | | | |
| Input Offset Voltage | V_{OS} | | | 0.5 | 3.5 | mV |
| | | | | | 4 | mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | | | 1 | | $\mu\text{V}/^\circ\text{C}$ |
| Input Bias Current (Note 10) | I_{IB} | | | 1 | | pA |
| | | | | | 1500 | pA |
| Input Offset Current (Note 10) | I_{OS} | | | 1 | | pA |
| | | | | | 1100 | pA |
| Channel Separation | XTLK | $f = 1\text{ kHz}$ | | 125 | | dB |
| Differential Input Resistance | R_{ID} | | | 10 | | $\text{G}\Omega$ |
| Common Mode Input Resistance | R_{IN} | | | 10 | | $\text{G}\Omega$ |
| Differential Input Capacitance | C_{ID} | | | 1 | | pF |
| Common Mode Input Capacitance | C_{CM} | | | 5 | | pF |
| Common Mode Rejection Ratio | CMRR | $V_{CM} = V_{SS} - 0.2$ to $V_{DD} + 0.2$ | 55 | 79 | | dB |
| | | $V_{CM} = V_{SS} + 0.2$ to $V_{DD} - 0.2$ | 51 | | | |

OUTPUT CHARACTERISTICS

| | | | | | | |
|------------------------|-----------|------------------------------------------------------------------------|-----------|-----|-----------|----|
| Open Loop Voltage Gain | A_{VOL} | | 90 | 120 | | dB |
| | | | 86 | | | |
| Short Circuit Current | I_{SC} | Output to positive rail, sinking current | | 15 | | mA |
| | | Output to negative rail, sourcing current | | 11 | | |
| Output Voltage High | V_{OH} | Voltage output swing from positive rail $V_{OH} = V_{DD} - V_{OUT}$ | | 3 | 24 | mV |
| | | | | | 25 | |
| Output Voltage Low | V_{OL} | Voltage output swing from negative rail $V_{OL} = V_{OUT} - V_{SS}$ | | 3 | 24 | mV |
| | | | | | 25 | |

AC CHARACTERISTICS

| | | | | | | |
|----------------------------|----------|---------------------------------------|------------------------|---------------|--|------------------------|
| Unity Gain Bandwidth | UGBW | | | 1.2 | | MHz |
| Slew Rate at Unity Gain | SR | $V_{IN} = 5\text{ Vpp}$, Gain = 1 | | 0.4 | | $\text{V}/\mu\text{s}$ |
| Phase Margin | ψ_m | | | 60 | | $^\circ$ |
| Gain Margin | A_m | | | 17 | | dB |
| Settling Time | t_S | $V_{IN} = 5\text{ Vpp}$, Gain = 1 | Settling time to 0.1% | 5 | | μs |
| | | | Settling time to 0.01% | 6 | | |
| Open Loop Output Impedance | Z_{OL} | | | See Figure 25 | | Ω |

NOISE CHARACTERISTICS

| | | | | | | |
|--------------------------------------|-------|----------------------------------------------------------|--|-------|--|------------------------------|
| Total Harmonic Distortion plus Noise | THD+N | $V_{IN} = 5\text{ Vpp}$, $f = 1\text{ kHz}$, $A_v = 1$ | | 0.005 | | % |
| Input Referred Voltage Noise | e_n | $f = 1\text{ kHz}$ | | 30 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| | | $f = 10\text{ kHz}$ | | 24 | | |
| Input Referred Current Noise | i_n | $f = 1\text{ kHz}$ | | 300 | | $\text{fA}/\sqrt{\text{Hz}}$ |

SUPPLY CHARACTERISTICS

| | | | | | | |
|--------------------------------|----------|----------------------|-----------|----|-----------|---------------|
| Power Supply Rejection Ratio | PSRR | No Load | 67 | 90 | | dB |
| | | | 64 | | | |
| Power Supply Quiescent Current | I_{DD} | Per channel, no load | | 48 | 70 | μA |

10. Performance guaranteed over the indicated operating temperature range by design and/or characterization.

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$, $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise specified

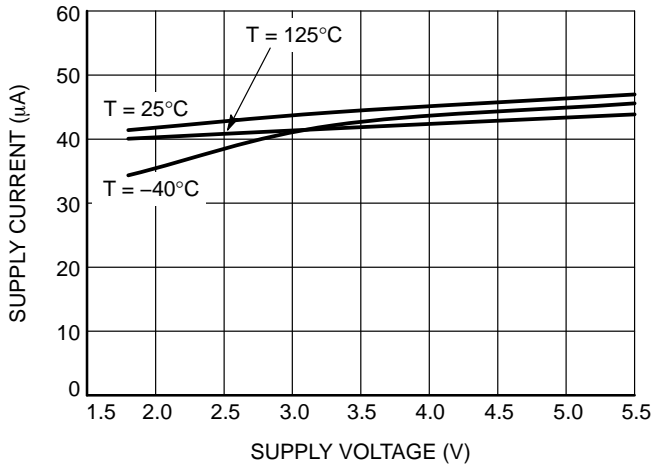


Figure 2. Quiescent Current per Channel vs. Supply Voltage

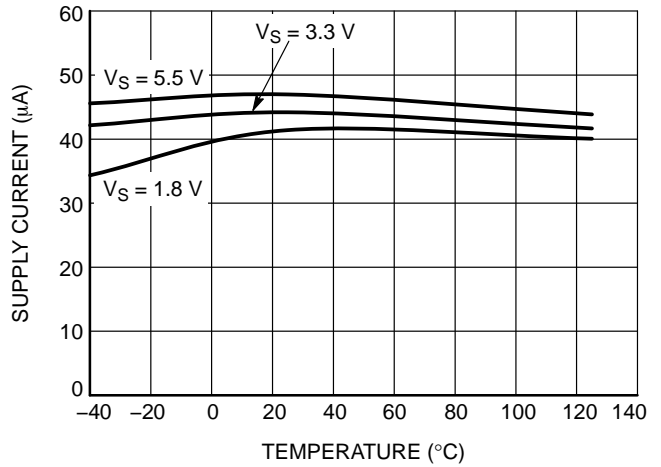


Figure 3. Quiescent Current vs. Temperature

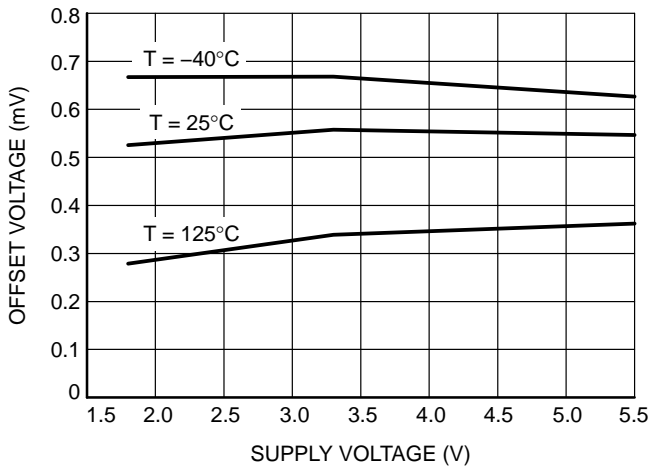


Figure 4. Offset Voltage vs. Supply Voltage

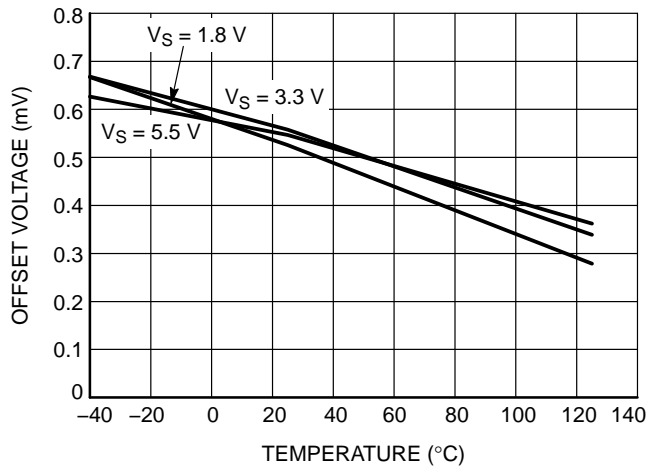


Figure 5. Offset Voltage vs. Temperature

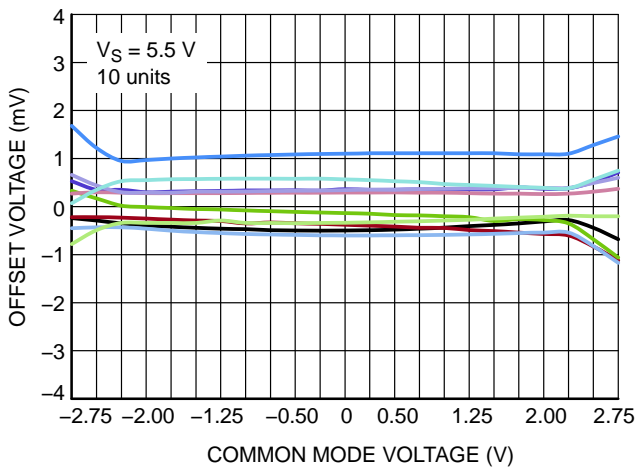


Figure 6. Offset Voltage vs. Common Mode Voltage

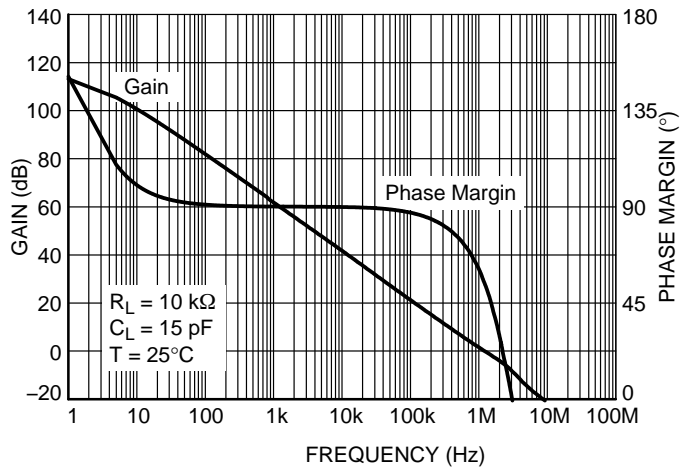


Figure 7. Open-loop Gain and Phase Margin vs. Frequency

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$, $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise specified

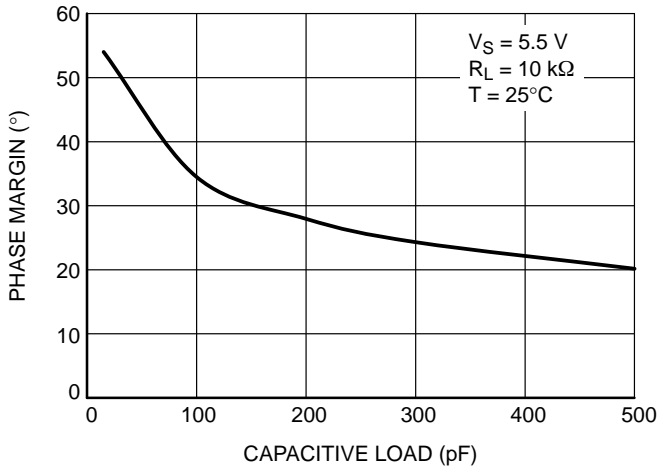


Figure 8. Phase Margin vs. Capacitive Load

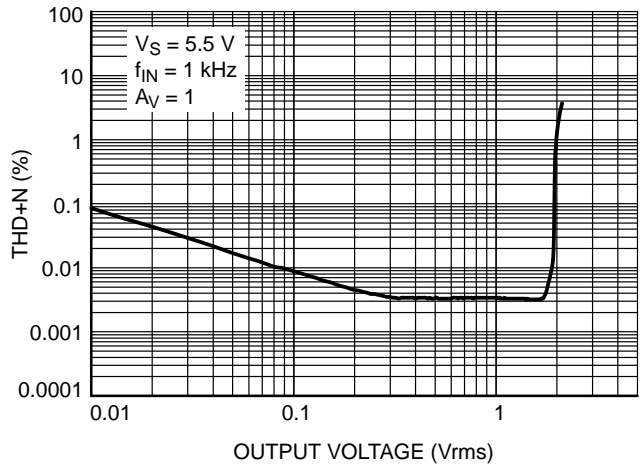


Figure 9. THD + N vs. Output Voltage

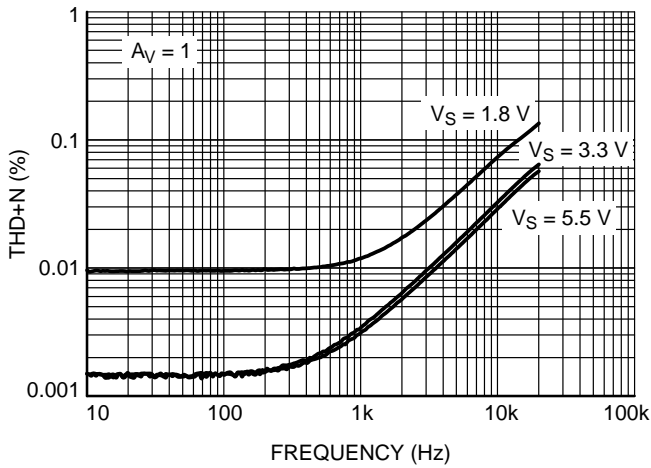


Figure 10. THD + N vs. Frequency

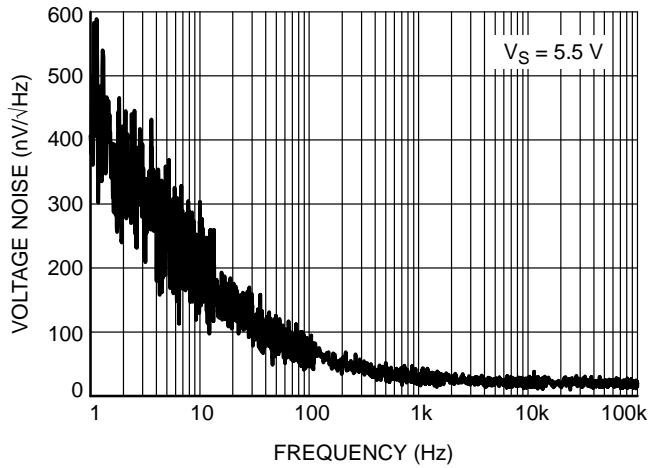


Figure 11. Input Voltage Noise vs. Frequency

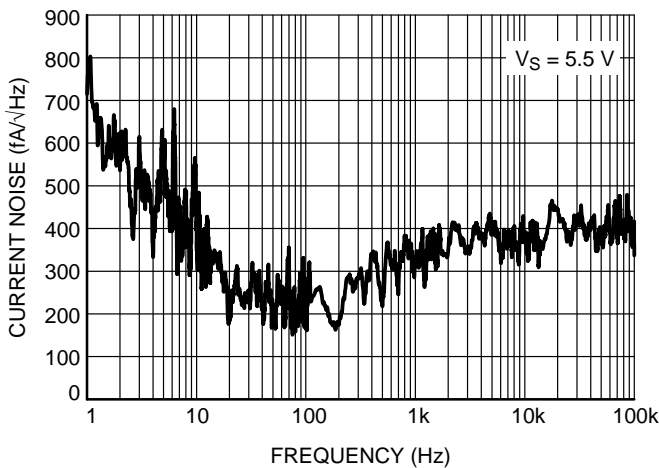


Figure 12. Input Current Noise vs. Frequency

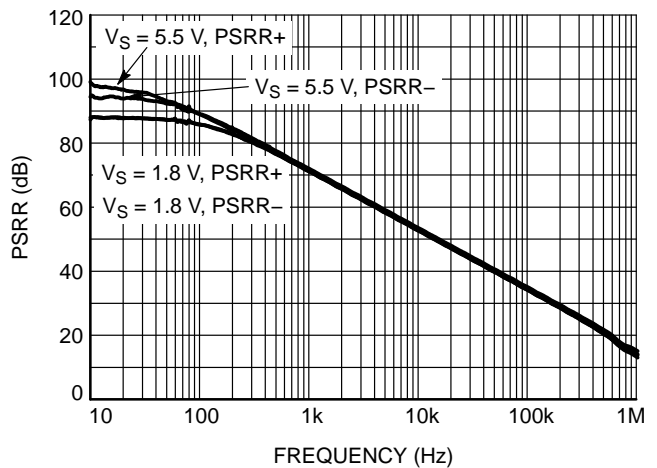


Figure 13. PSRR vs. Frequency

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$, $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise specified

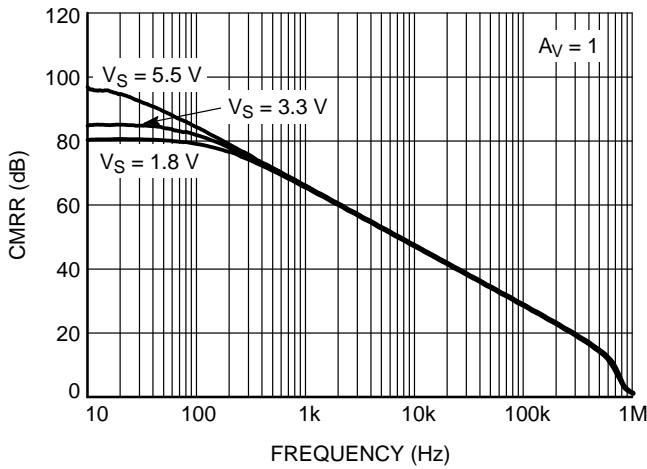


Figure 14. CMRR vs. Frequency

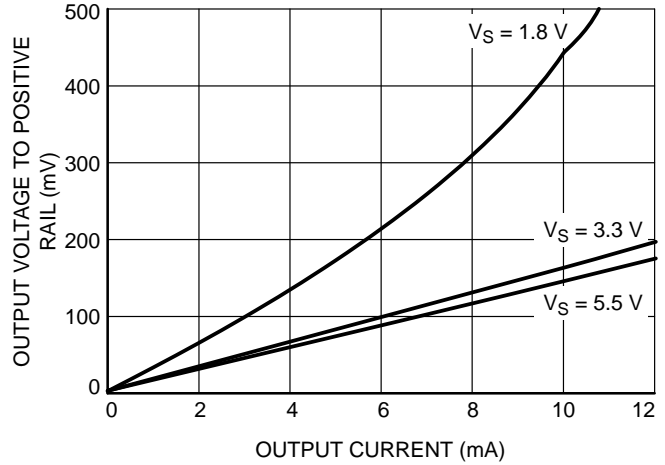


Figure 15. Output Voltage High to Rail

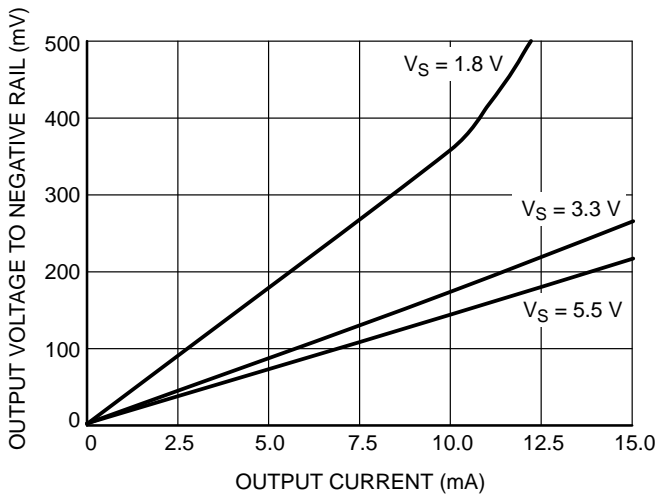


Figure 16. Output Voltage Low to Rail

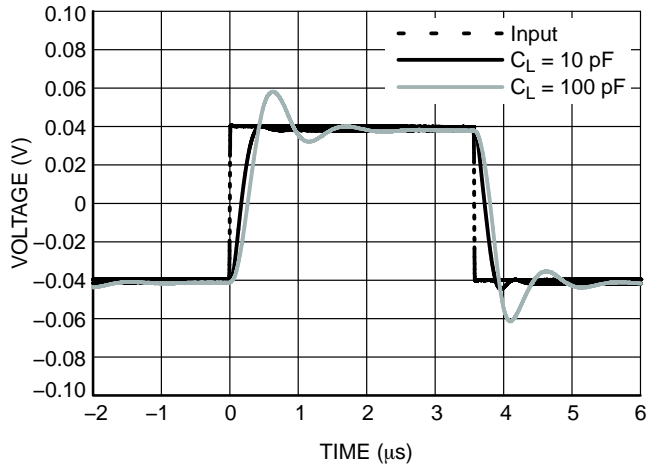


Figure 17. Non-Inverting Small Signal Transient Response

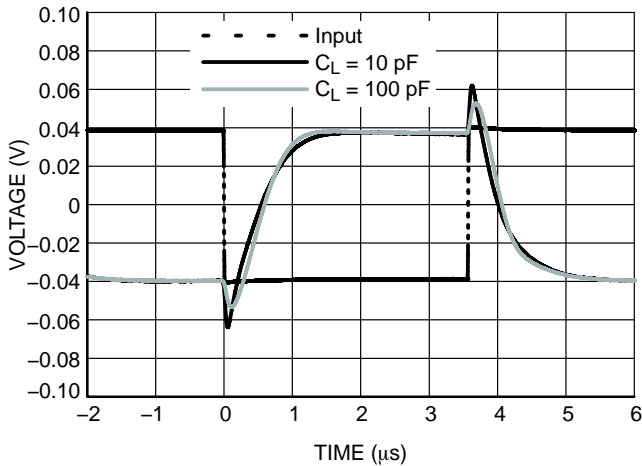


Figure 18. Inverting Small Signal Transient Response

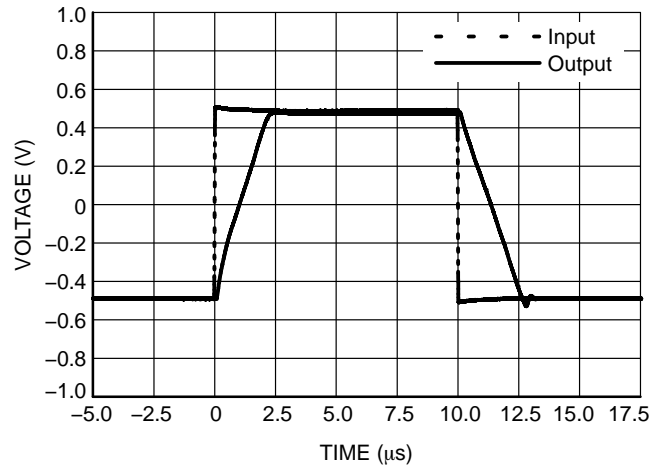


Figure 19. Non-Inverting Large Signal Transient Response

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$, $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise specified

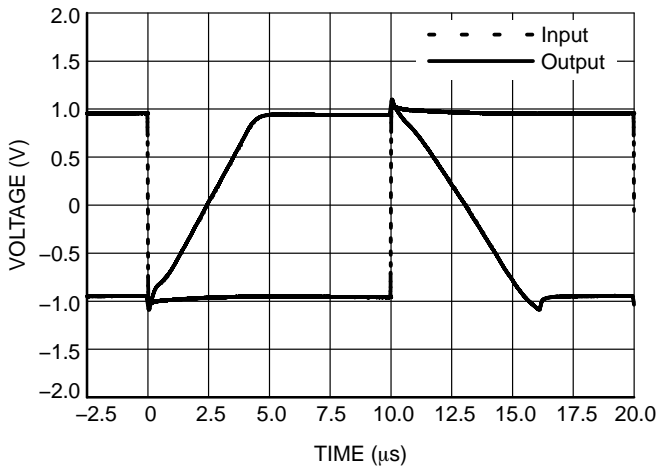


Figure 20. Inverting Large Signal Transient Response

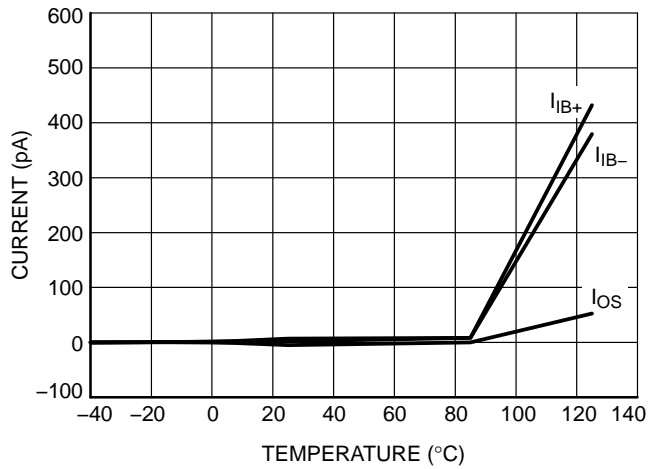


Figure 21. Input Bias and Offset Current vs. Temperature

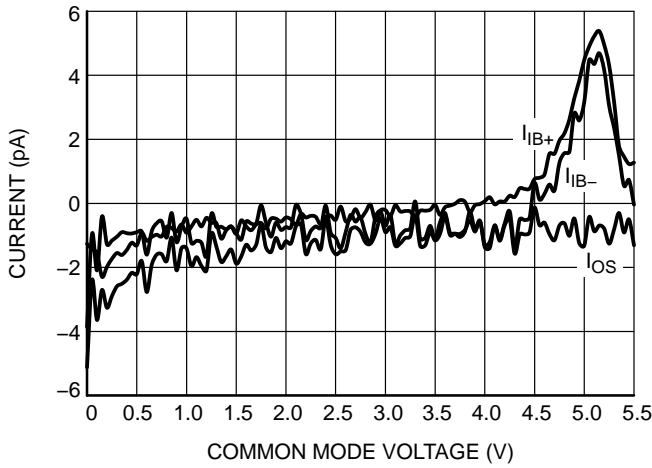


Figure 22. Input Bias Current vs. Common Mode Voltage

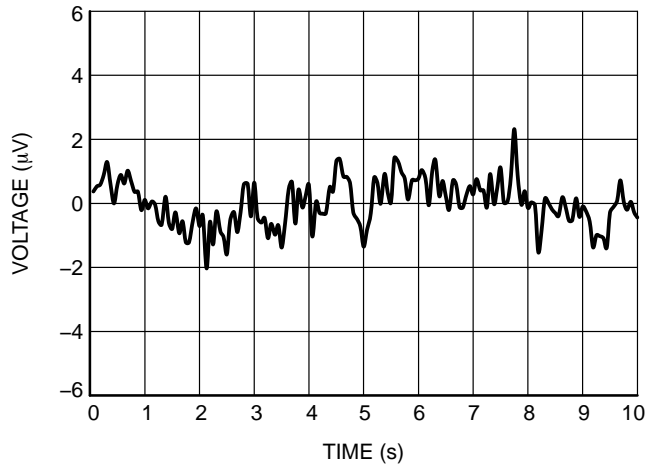


Figure 23. 0.1 Hz to 10 Hz Noise

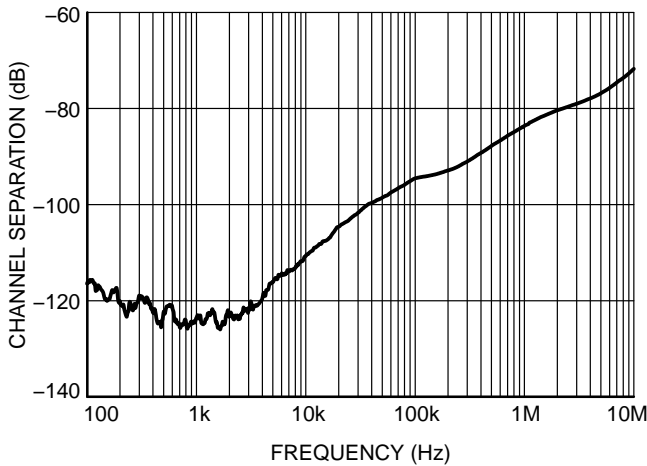


Figure 24. Channel Separation vs. Frequency

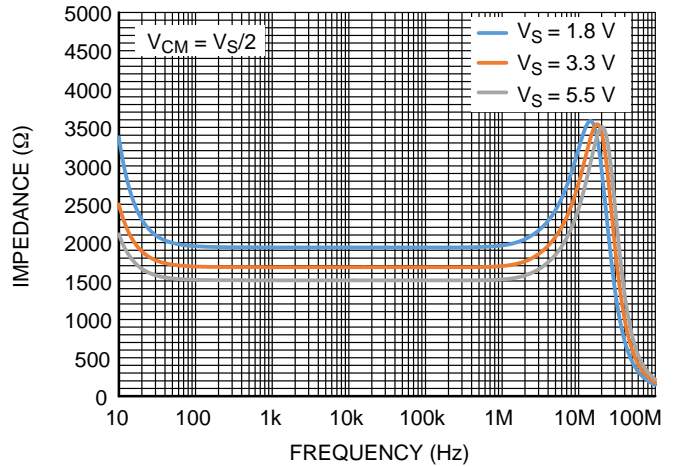


Figure 25. Open Loop Output Impedance vs. Frequency

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$, $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise specified

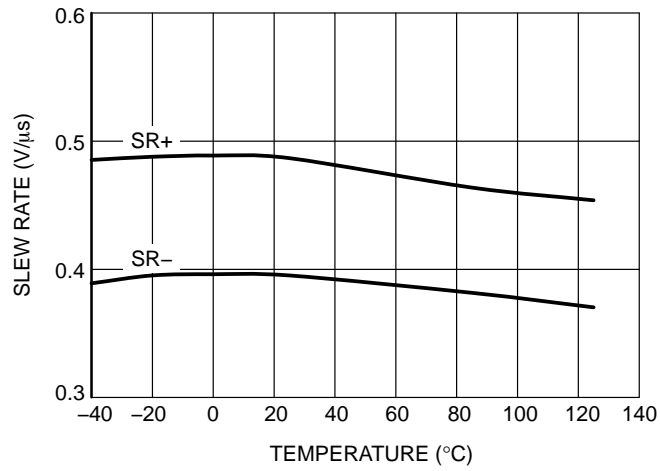
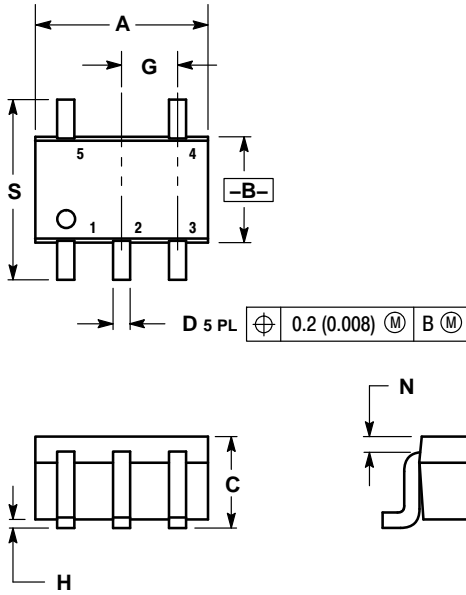


Figure 26. Slew Rate vs. Temperature

PACKAGE DIMENSIONS

SC-88A (SC-70-5/SOT-353)
CASE 419A-02
ISSUE L

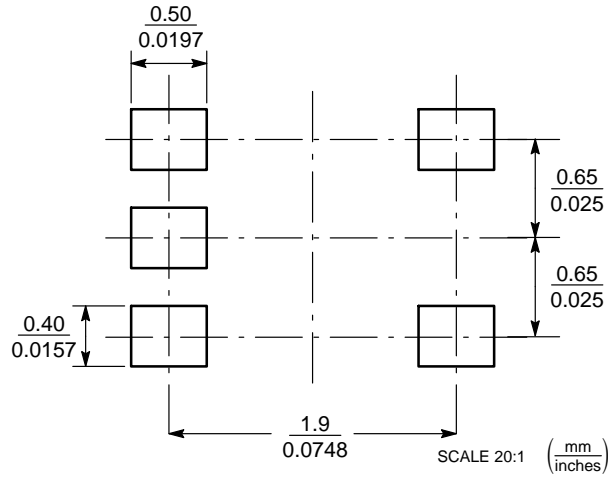


NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. 419A-01 OBSOLETE. NEW STANDARD 419A-02.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

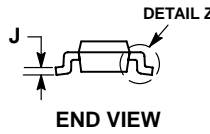
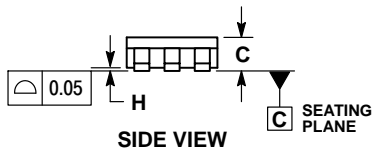
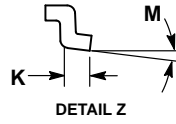
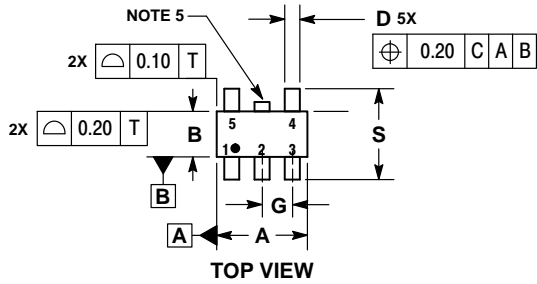
| DIM | INCHES | | MILLIMETERS | |
|-----|-----------|-------|-------------|------|
| | MIN | MAX | MIN | MAX |
| A | 0.071 | 0.087 | 1.80 | 2.20 |
| B | 0.045 | 0.053 | 1.15 | 1.35 |
| C | 0.031 | 0.043 | 0.80 | 1.10 |
| D | 0.004 | 0.012 | 0.10 | 0.30 |
| G | 0.026 BSC | | 0.65 BSC | |
| H | --- | 0.004 | --- | 0.10 |
| J | 0.004 | 0.010 | 0.10 | 0.25 |
| K | 0.004 | 0.012 | 0.10 | 0.30 |
| N | 0.008 REF | | 0.20 REF | |
| S | 0.079 | 0.087 | 2.00 | 2.20 |

SOLDER FOOTPRINT



PACKAGE DIMENSIONS

TSOP-5
CASE 483
ISSUE L

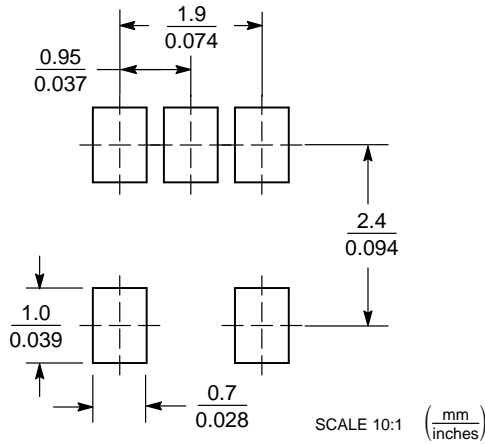


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE. DIMENSION A.
5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.

| DIM | MILLIMETERS | |
|-----|-------------|------|
| | MIN | MAX |
| A | 3.00 BSC | |
| B | 1.50 BSC | |
| C | 0.90 | 1.10 |
| D | 0.25 | 0.50 |
| G | 0.95 BSC | |
| H | 0.01 | 0.10 |
| J | 0.10 | 0.26 |
| K | 0.20 | 0.60 |
| M | 0° | 10° |
| S | 2.50 | 3.00 |

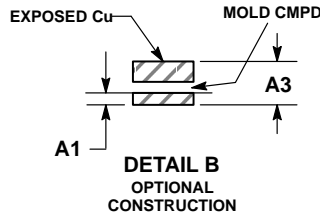
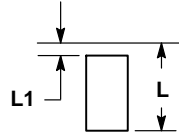
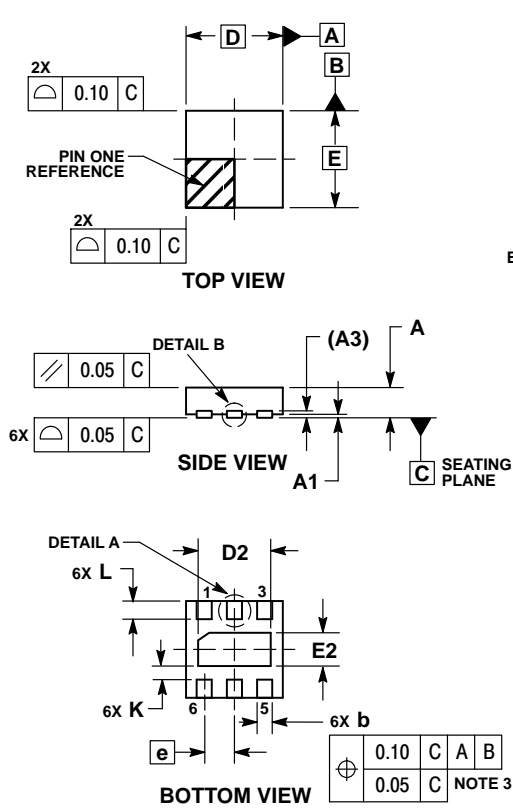
SOLDERING FOOTPRINT*



*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

UDFN6 1.6x1.6, 0.5P
CASE 517AP
ISSUE O

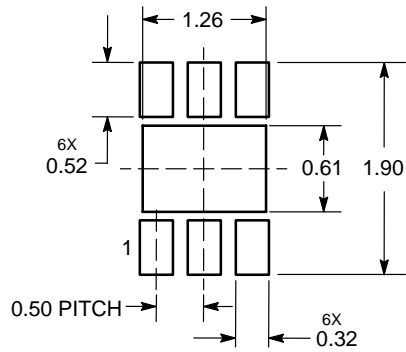


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 mm FROM TERMINAL.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

| MILLIMETERS | | |
|-------------|------|------|
| DIM | MIN | MAX |
| A | 0.45 | 0.55 |
| A1 | 0.00 | 0.05 |
| A3 | 0.13 | REF |
| b | 0.20 | 0.30 |
| D | 1.60 | BSC |
| E | 1.60 | BSC |
| e | 0.50 | BSC |
| D2 | 1.10 | 1.30 |
| E2 | 0.45 | 0.65 |
| K | 0.20 | --- |
| L | 0.20 | 0.40 |
| L1 | 0.00 | 0.15 |

SOLDERMASK DEFINED MOUNTING FOOTPRINT*

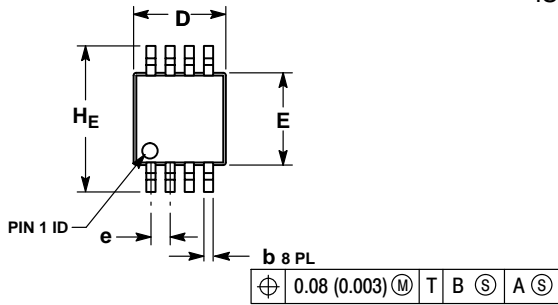


DIMENSIONS: MILLIMETERS

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

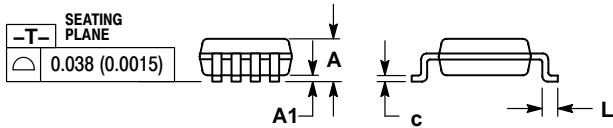
PACKAGE DIMENSIONS

Micro8™
CASE 846A-02
ISSUE J

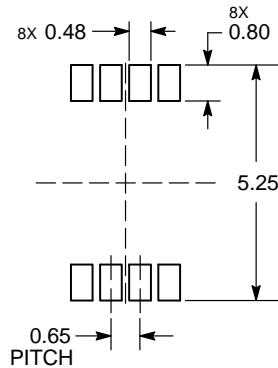


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: MILLIMETER.
 3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
 4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
 5. 846A-01 OBSOLETE, NEW STANDARD 846A-02.

| DIM | MILLIMETERS | | | INCHES | | |
|-----|-------------|------|------|-----------|-------|-------|
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | — | — | 1.10 | — | — | 0.043 |
| A1 | 0.05 | 0.08 | 0.15 | 0.002 | 0.003 | 0.006 |
| b | 0.25 | 0.33 | 0.40 | 0.010 | 0.013 | 0.016 |
| c | 0.13 | 0.18 | 0.23 | 0.005 | 0.007 | 0.009 |
| D | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| E | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| e | 0.65 BSC | | | 0.026 BSC | | |
| L | 0.40 | 0.55 | 0.70 | 0.016 | 0.021 | 0.028 |
| HE | 4.75 | 4.90 | 5.05 | 0.187 | 0.193 | 0.199 |



RECOMMENDED
SOLDERING FOOTPRINT*

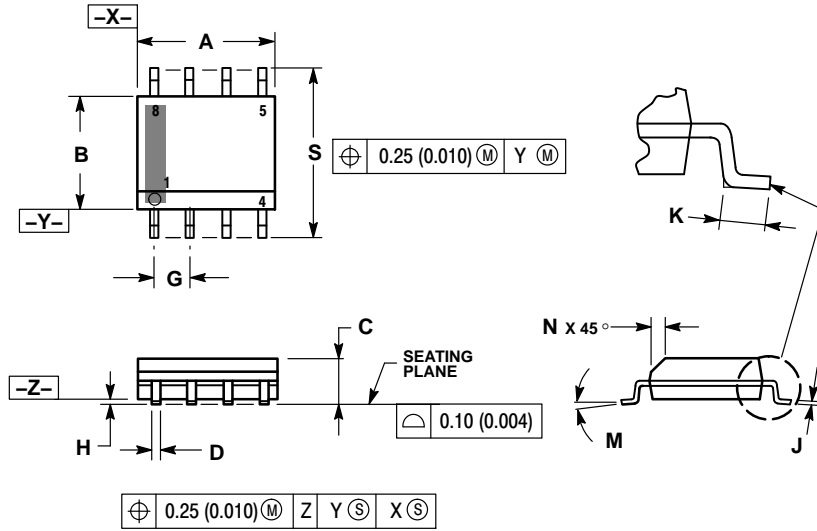


DIMENSION: MILLIMETERS

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

SOIC-8 NB
CASE 751-07
ISSUE AK

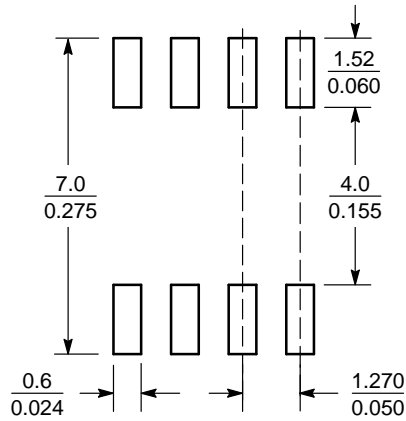


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: MILLIMETER.
 3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
 4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
 5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
 6. 751-01 THRU 751-06 ARE OBSOLETE. NEW STANDARD IS 751-07.

| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|------|-----------|-------|
| | MIN | MAX | MIN | MAX |
| A | 4.80 | 5.00 | 0.189 | 0.197 |
| B | 3.80 | 4.00 | 0.150 | 0.157 |
| C | 1.35 | 1.75 | 0.053 | 0.069 |
| D | 0.33 | 0.51 | 0.013 | 0.020 |
| G | 1.27 BSC | | 0.050 BSC | |
| H | 0.10 | 0.25 | 0.004 | 0.010 |
| J | 0.19 | 0.25 | 0.007 | 0.010 |
| K | 0.40 | 1.27 | 0.016 | 0.050 |
| M | 0° | 8° | 0° | 8° |
| N | 0.25 | 0.50 | 0.010 | 0.020 |
| S | 5.80 | 6.20 | 0.228 | 0.244 |

- STYLE 11:
- PIN 1. SOURCE 1
2. GATE 1
3. SOURCE 2
4. GATE 2
5. DRAIN 2
6. DRAIN 2
7. DRAIN 1
8. DRAIN 1

SOLDERING FOOTPRINT*

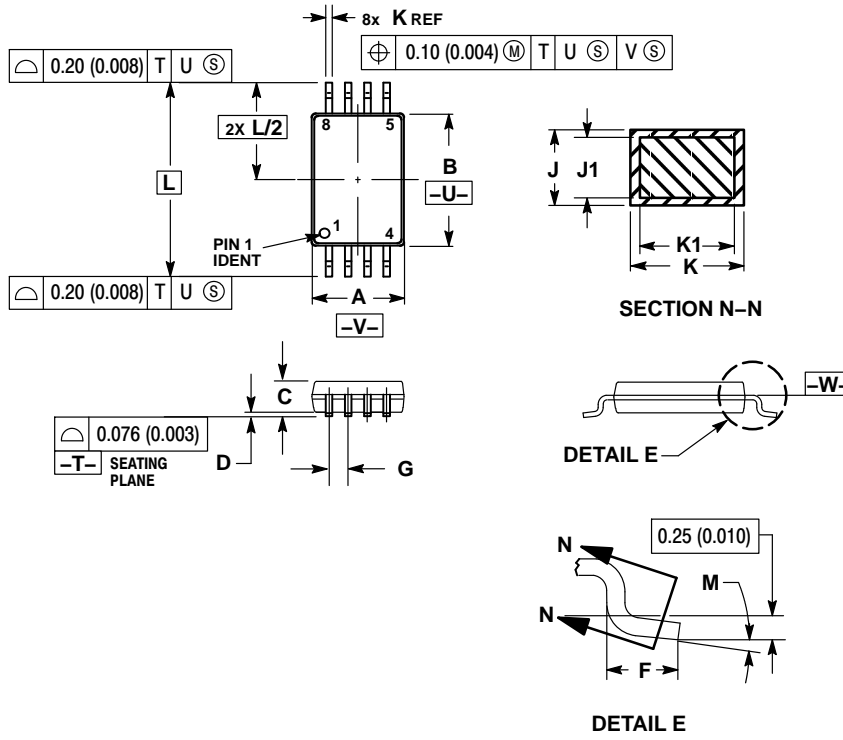


SCALE 6:1 ($\frac{\text{mm}}{\text{inches}}$)

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

TSSOP-8
CASE 948S
ISSUE C

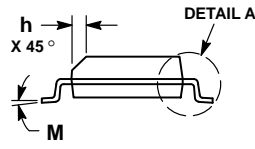
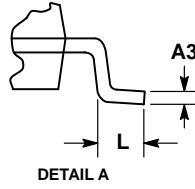
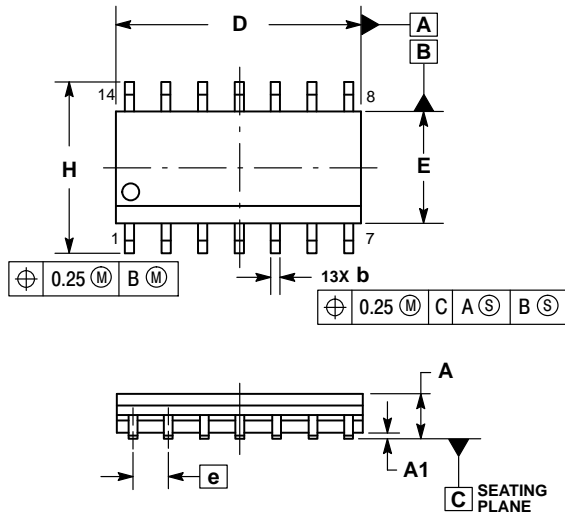


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: MILLIMETER.
 3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
 4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
 5. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
 6. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|------|-----------|-------|
| | MIN | MAX | MIN | MAX |
| A | 2.90 | 3.10 | 0.114 | 0.122 |
| B | 4.30 | 4.50 | 0.169 | 0.177 |
| C | --- | 1.10 | --- | 0.043 |
| D | 0.05 | 0.15 | 0.002 | 0.006 |
| F | 0.50 | 0.70 | 0.020 | 0.028 |
| G | 0.65 BSC | | 0.026 BSC | |
| J | 0.09 | 0.20 | 0.004 | 0.008 |
| J1 | 0.09 | 0.16 | 0.004 | 0.006 |
| K | 0.19 | 0.30 | 0.007 | 0.012 |
| K1 | 0.19 | 0.25 | 0.007 | 0.010 |
| L | 6.40 BSC | | 0.252 BSC | |
| M | 0° | 8° | 0° | 8° |

PACKAGE DIMENSIONS

SOIC-14 NB
CASE 751A-03
ISSUE K

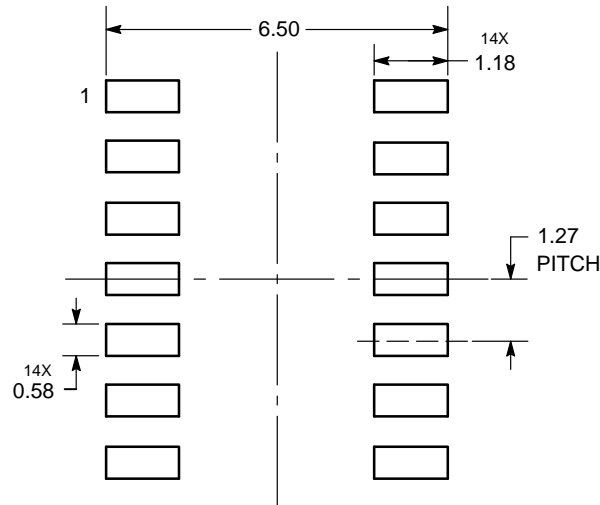


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.13 TOTAL IN EXCESS OF AT MAXIMUM MATERIAL CONDITION.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD PROTRUSIONS.
5. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.

| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|------|-----------|-------|
| | MIN | MAX | MIN | MAX |
| A | 1.35 | 1.75 | 0.054 | 0.068 |
| A1 | 0.10 | 0.25 | 0.004 | 0.010 |
| A3 | 0.19 | 0.25 | 0.008 | 0.010 |
| b | 0.35 | 0.49 | 0.014 | 0.019 |
| D | 8.55 | 8.75 | 0.337 | 0.344 |
| E | 3.80 | 4.00 | 0.150 | 0.157 |
| e | 1.27 BSC | | 0.050 BSC | |
| H | 5.80 | 6.20 | 0.228 | 0.244 |
| h | 0.25 | 0.50 | 0.010 | 0.019 |
| L | 0.40 | 1.25 | 0.016 | 0.049 |
| M | 0° | 7° | 0° | 7° |

SOLDERING FOOTPRINT*

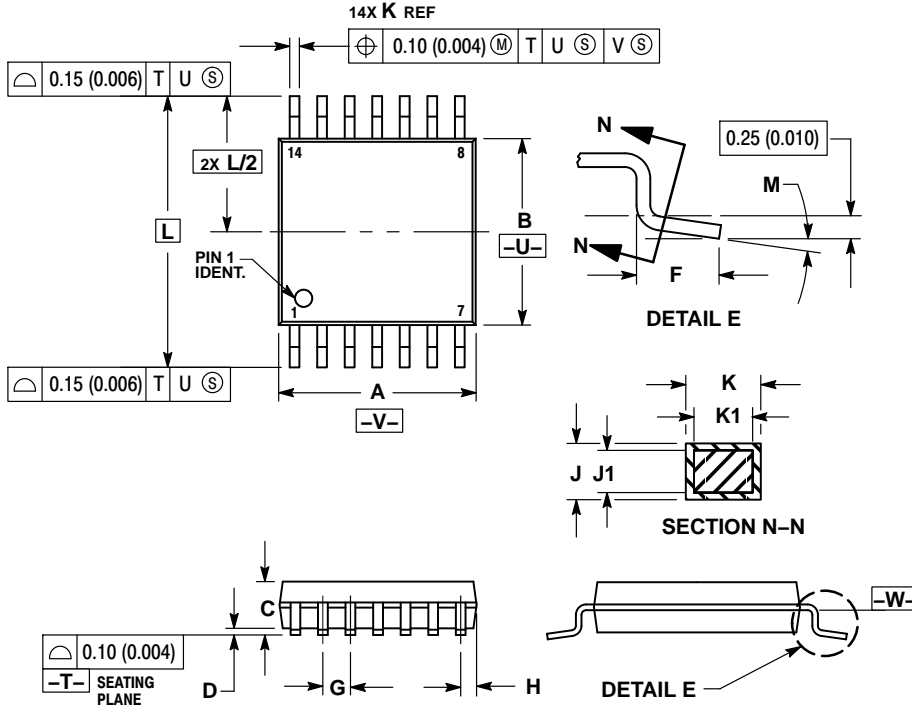


DIMENSIONS: MILLIMETERS

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

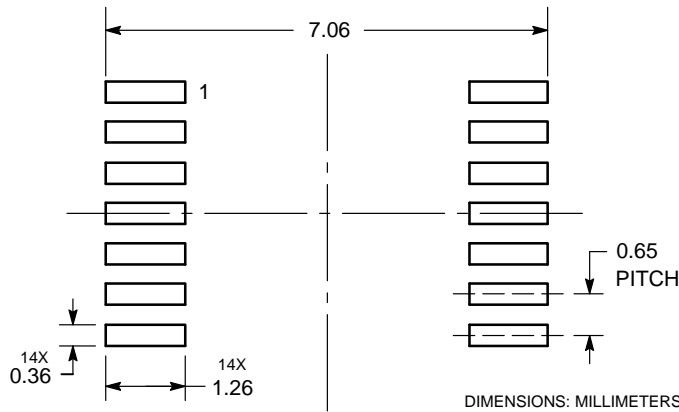
TSSOP-14
CASE 948G
ISSUE B



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: MILLIMETER.
 3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
 4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
 5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
 6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
 7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|------|-----------|-------|
| | MIN | MAX | MIN | MAX |
| A | 4.90 | 5.10 | 0.193 | 0.200 |
| B | 4.30 | 4.50 | 0.169 | 0.177 |
| C | --- | 1.20 | --- | 0.047 |
| D | 0.05 | 0.15 | 0.002 | 0.006 |
| F | 0.50 | 0.75 | 0.020 | 0.030 |
| G | 0.65 BSC | | 0.026 BSC | |
| H | 0.50 | 0.60 | 0.020 | 0.024 |
| J | 0.09 | 0.20 | 0.004 | 0.008 |
| J1 | 0.09 | 0.16 | 0.004 | 0.006 |
| K | 0.19 | 0.30 | 0.007 | 0.012 |
| K1 | 0.19 | 0.25 | 0.007 | 0.010 |
| L | 6.40 BSC | | 0.252 BSC | |
| M | 0° | 8° | 0° | 8° |

SOLDERING FOOTPRINT



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